Supporting STEM knowledge and skills in engineering education – PELARS project

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Abstract

In this paper we present our proposal for improving education with hands-on, project-based and experimental scenarios for engineering students with the use of learning analytics. We accomplish this through teacher and learner engagement, user studies and evaluated trials, performed at UCV (University of Craiova, Romania) and DTU (Technical University of Denmark). The PELARS project (Practice-based Experiential Learning Analytics Research And Support) provides technological tools and ICT-based methods for collecting activity data (moving image-based and embedded sensing) for learning analytics (data-mining and reasoning) of practice-based and experiential STEM. This data is used to create analytics support tools for teachers, learners and administrators, providing frameworks for evidence-based curriculum design and learning systems. The PELARS project creates behavioral recording inputs, proving a new learning analytic that is scalable in application, and bridge qualitative and quantitative methods through reasoning and feedback from input data. The project serves to better understand learners' knowledge in physical activities in laboratory and workshop environments, as well as informal learning scenarios. PELARS traces and helps assess learner progress through technology enhancement, in novel ways building upon current research. The project results in learning analytics tools for practice-based STEM learning that are appropriate for real-world learning environments.

Introduction

The PELARS[1] project is intended as a testing ground and generator of 21st-Century STEM knowledge and skills. The project generates, analyses, uses and provides feedback for analytics derived from hands-on, project-based and experiential learning scenarios. These scenarios are:

1. European High School level STEM classrooms.
2. Postsecondary Science and Engineering practical environments.
3. The more open-form studio environments of the Interaction Design Schools (which form the basis and inspiration for many of the project's orientations).

The project serves to help better understand learners' knowledge in physical activities in laboratory and workshop environments, as well as informal learning scenarios. PELARS traces and helps assess learner progress through technology enhancement, in ways that have been un-attempted and un-scalable until now. The project results in learning analytics tools for practice-based STEM learning that are appropriate for real-world learning environments.

The participants of the PELARS project are twelve European Partners that have all been chosen for their specific expertise and skills in the fields of this project. The Consortium includes seven universities, three small medium enterprises and two non-profit organizations. The partners are from ten different countries (Belgium, Denmark, Germany, Ireland, Italy, Romania, Spain,

Sweden, Switzerland and United Kingdom). This geographical distribution is due to the desire to build a Consortium mainly based on a thematic structure, and aimed at achieving a large interdisciplinary network of excellence. All the named learning objectives are defined across four national settings in the EU.

User Experience in Engineering Education

The objective of Work Package 2 in PELARS-project is to engage, through design ethnography methodologies and on-site experience prototyping, with groups and individuals involved in teaching and learning of STEM subjects in three different contexts[2,3] and one of them is engineering education context[4,5,6]. UCV from Romania and DTU from Denmark are the two engineering higher education institutions where the new PELARS technology has to be tested. The first test has been done at UCV in July 2015 and the second one is scheduled at DTU in April 2016.

Taking into consideration the PELARS objectives we are interested to investigate the different users' opinions (students and teachers) regarding the features offered by PELARS technology and what could be added or modified. An important aspect in our definition is use of learning analytics resulting from the use of these new educational technologies.

In the frame of PELARS we are working to develop new technologies and processes for teaching and learning for design, engineering (as part of STEM) through practical applications[7,8,9,10] .

The technological developments in the last 10-15 years and wide use of the new technologies like tablets, smartphones and information sources on internet, changed everyday life and have the big impact on teaching's methods. It is important to modernize and adapt the educational system to new generation of students, who grown up with and use the named technological tools[11,12,13]. The complexity of new technologies made it also necessary to prepare the students for even more challenging future, where abilities to cooperate and self-study are also included. In this context, we ask the following questions:

- What it is needed to change in the actual educational methods at the two partner universities, UCV and DTU, to perform practical experiments supporting students' motivation?
- How PELARS technology could contribute to support the named abilities/skills?
- What is the impact of the PELARS' technology seen from the final users: students and teachers?
- Will the new technology change the accreditation procedures?

The schedule for trials in PELARS is shown in figure 1.

Creating a comprehensive plan for each of the trials include also ethics considerations. All activities are and will be carried out taking into account FP7 guidelines as well as national guidelines on ethic issues, guaranteed by the Ethics Committee under EU. Participation of users is in line with agreed European and National ethical procedures for user participation and remuneration of test subjects, and subject to sign off by the Ethics and Research committees.

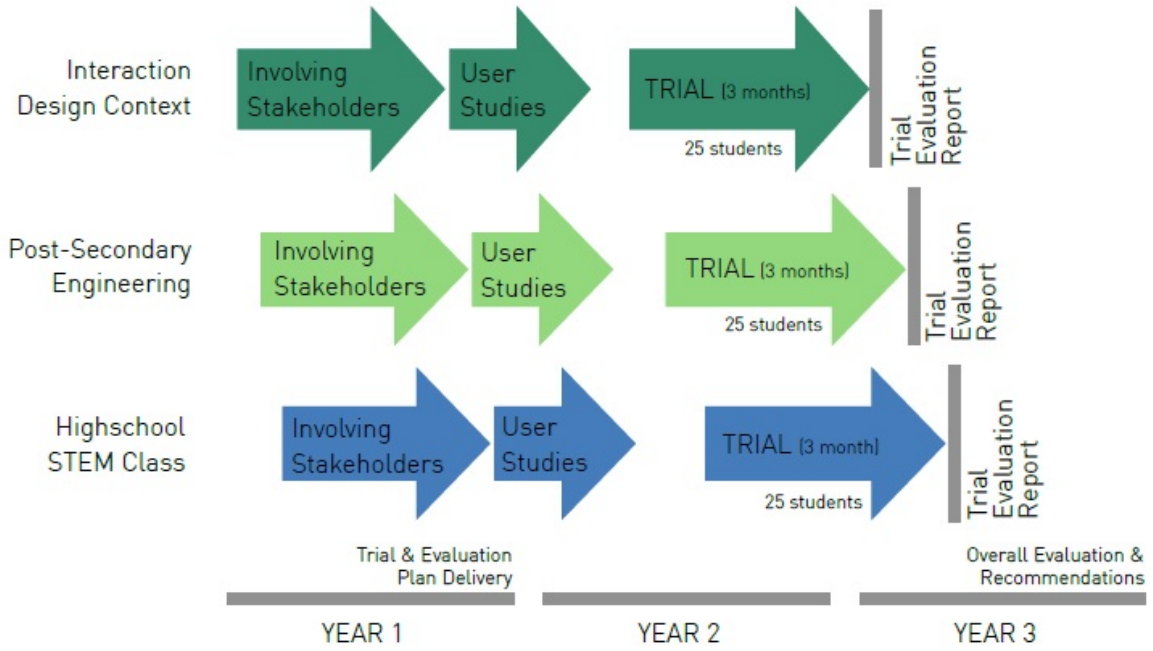

Figure 1. The schedule for PELARS' trials.

Both legal and ethical issues are a priori approved by European Commission and national authorities prior to conducting any trials, and the appropriate materials (project in accordance to the EC's Ethical Guidelines for undertaking ICT research in FP7[14]).
Each year every partner of PELARS project has to provide signed "Ethics declaration", including Section 5, as shown in figure 2.

Section 5 Ethical issues

What are the ethical issues which may arise in the course of this research, **and how will they be addressed?** Please consider / address ALL issues that may apply.

- Potentially vulnerable participants
- Safeguarding/child protection
- Risks to participants and/or researchers
- International research
- Sensitive topics
- Sampling
- Gatekeepers
- Informed consent
- Assent
- Methods
- Confidentiality
- Anonymity
- Data storage/security
- Data transfer/transmission
- Data sharing/encryption
- Data documentation
- Data management plan
- Data protection
- Reporting
- Dissemination and use of findings

e.g. There are no major ethical issues arising from this phase of the research. The issues that concern us are as follows:
- Voluntary teacher/lecturer participation vis-à-vis participation being imposed by head teachers or management
- Working with young people requires special consideration to their circumstances. In order to address these issues we will take the following steps:
- Participants will be provided with information leaflets and consent forms (see attached samples)
- The project partner is responsible for consent forms signature and storage for 3 years after the project end
- We will ensure that we use participant codes to anonymize the data we collect.

We will only analyse audio, video or photographic data with written consent from teachers, headteachers, students and their parents, and only for the purpose of reporting in academic outputs (for example, in conference presentations). We will publish anonymized reports of the data.
- Students can withdraw anytime
- [...]

Figure 2. Ethics declaration, section 5.

Learning activities/prototyping at UCV

In the summer of 2015 we organized a workshop at UCV, Craiova having the support and direct participation of two partners from Sweden and UK. We had a two-day workshop at UCV with students from two programs: Mechatronics and Robotics (more practical oriented) and Multimedia Engineering Systems (more software oriented and with a better theoretical background) and two group interviews with teachers (mixed subjects). We collected students' feedback on the latest learning activities we had developed at that time. We wanted to hear, in a dialogue with other people than their own teachers, how they consider the actual way to perform laboratory activities (labs) compared to PELARS proposals. We put together engineering students to see how students from different programs are able to work together by proposing solutions for different problems without using a specific theoretical base. The main goal was to obtain and to discuss few proposals generated by students for practical scenarios that can be possibly used to teach with for labs using PELARS technology, methods and equipment. We investigated UCV teachers' perspectives about their current practice of laboratory sessions and their ideas about how to integrate PELARS technologies in their teaching practice. The data collection was done in an informal focus group interview setting and was audio recorded. Workshops are video and audio recorded and interviews are audio recorded for future references.

Student workshops were planned as follows:

- Introduction to PELARS project-Presentation
- Research consent forms
- Introduction to visual programming platform
- Presentation of educational scenarios
- Introduction to brainstorming
- Brainstorming about the learning activities
- Three questions about the learning activities.

The number of participants was 14 for 13th of July, and 15 for the 14th of July. Students were from the programs of Mechatronics & Robotics (third year of study), respectively from Multimedia Engineering Systems (second year of study). Both programs offer a bachelor diploma in engineering after 4 years of study. During the workshop a number of six teachers from UCV (two professors, two associate professors, and two assistant professors), all with PhD in engineering, were involved.

Summarized the comments on PELARS trials at UCV were following:

- The proposed educational technology looks attractive and interesting compared with the methods used at UCV at the moment, which are based on learning a lot of theory without enough creative and cooperative experiments.
- A number of UCV students have a good experience in using Arduino components and building systems using mechanical and electronics parts, and because of that they appreciated the new proposal.
- Students with good practical skills see in the new educational technology a way to counteract with students with better theoretical skills.

Practice-Based and Experiential Learning at DTU

In Denmark there is traditionally close cooperation between engineering educational institutions and the industry, which is the employee for engineering graduates. Due to this tradition DTU make ongoing changes in programs and educational methods, as a result of discussion with our industrial partners. The requirements from industry include also skills like teamwork, project-work and ability to self-study. This is the reason why students at DTU work from the very beginning (first semester) in groups solving practical engineering problems related to the theoretical subjects. Even the basic subjects like mathematics and physics are connected with design-build projects, where students work in teams with the project combining all theoretical subjects. This is quite a different educational approach to teaching theory from the methods used at UCV and this is why our trials at DTU are expected to have different focus from the trials performed at UCV. The DTU trials are scheduled for April 2016 with different groups of DTU's students, involving students from Electronics-, Software- and Electrical Power - programs. At DTU we will focus on several requirements of suitable PELARS toolkits, which should have following properties:

- Flexibility in the adaptation of learning activities to teachers' practice at DTU. PELARS learning activities should define a general curriculum area, but allow teachers to design specific projects within that curriculum area that target their chosen knowledge, skills and competencies;
- A primary focus on skills and competencies, and secondary focus on specific curriculum knowledge;
- A focus on motivating students to engage with STEM;

Relevant learning objectives are:

- Programming: abstracting actions into algorithms, coding an algorithm (knowing the syntax), debugging programs;
- Circuiting: (depending on toolkit:) working with breadboards / soldering / connecting components, debugging circuits;
- Working with sensors, and actuators, mapping analogue values to quantized digital values;
- Planning and conducting projects;
- STEM projects: setting up experiments, measuring data, visualizing data;
- Creativity: idea generation, design, practical skills.

Conclusion

We have identified programs in undergraduate engineering education that will assist the PELARS project to both develop and evaluate learning analytics for practice-based learning. The first practical experiment has been made at UCV and next one is scheduled at DTU in April 2016. The following trials at UCV and DTU will include changes how to best support learning analytics with PELARS due to the conclusions of the first two trials. The two engineering institutions, UCV and

DTU, have similar engineering programs, but the traditional teaching methods are different and the requirements from the national bodies to certificate the educations. Our aim is to develop a framework of learning objectives that are relevant to real-world learning contexts and within which the PELARS consortium can develop and evaluate both the technical possibility and real world relevance of learning analytics for practice-based learning in different countries.

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Bibliography

1. PELARS-project, http://www.pelars.eu/
2. Blikstein, P.: "Multimodal learning analytics"; Proceedings of the Third International Conference on Learning Analytics and Knowledge ((2013, April, pp. 102-106).
3. Worsley, M.: "Multimodal Learning Analytics as a Tool for Bridging Learning Theory and Complex Learning Behaviors"; *Proceedings of the 2014 ACM workshop on Multimodal Learning Analytics Workshop and Grand Challenge* (2014, November, pp. 1-4).
4. Friesel**, A.,** Timcenko**, O.: "**Mathematical Modelling in Electronics and Medialogy – Sharing Experiences for Better Results", ICEE2011 - August 2011, Belfast, North Ireland, **UK.**
5. Friesel,A., Avramides, K., Cojocaru, D.: "Identifying how PELARS-project can support the development of new curriculum structures in engineering education", The Experimental International Conference 2015 (**exp.at'15**), June, 2015, University of Azores, Ponta Delgada, São Miguel Island, Azores, Portugal.
6. Krumm, A.E.; Waddington, R.J.; Lonn, S.; Teasley, S.D. :" Increasing Academic Success in Undergraduate Engineering Education using Learning Analytics: A Design-Based Research Project"; Annual Meeting of the American Educational Research Association. Vancouver, BC, Canada, 2012-04 ; . http://hdl.handle.net/2027.42/106032
7. Dragon, T., Mavrikis, M., McLaren, B.M., Harrer, A., Kynigos, C., Wegerif, R., & Yang, Y.: "Metafora: A web-based platform for learning to learn together in science and mathematics". IEEE Transactions on Learning Technologies, 6(3), 197-207; JULY-SEPTEMBER 2013.
8. Minović, M., Milovanović, M. (2013): "Real-time learning analytics in educational games". Proceedings of the First International Conference on Technological Ecosystem for Enhancing Multiculturality - TEEM '13 (pp. 245–251). New York, New York, USA.
9. Cuartielles, D.: "Final STEM Learning Kit with Integrated Learning Analytics". PELARS Project Deliverable D4.2, October 2015. https://docs.google.com/document/d/1Vt-r9PBFGus2AG7SErlGVg8JUkfPLs9n2wX2zfL8rws/edit#heading=h.hcfjfl2xwvzm
10. Martinez-Maldonado, R., Dimitriadis, Y., Martinez-Monés, A., Kay, J., & Yacef, K.: "Capturing and analyzing verbal and physical collaborative learning interactions at an enriched interactive tabletop". International Journal of Computer-Supported Collaborative Learning, 2013, 8(4), pp. 455-485.
11. Martinez-Maldonado, R., Pardo, A., Mirriahi, N., Yacef, K., Kay, J., & Clayphan, A. The LATUX workflow: designing and deploying awareness tools in technology-enabled learning settings. Proceedings of the Fifth International Conference on Learning Analytics And Knowledge (2015, March, pp. 1-10).
12. Mavrikis, M.;, Gutierrez-Santos, S, Geraniou, E, Noss, R & Poulovassilis, A.: "Iterative Context Engineering to Inform the Design of Intelligent Exploratory Learning Environments for the Classroom"; in R Luckin, S Puntambekar, P Goodyear, BL Grabowski, J Underwood & N Winters (eds), Handbook of Design in Educational Technology. Routledge, 2013, pp. 80-92.

13. Vogel, B.; Spikol, D.; Kurti, A.; Milrad,M.: ”Integrating Mobile, Web and Sensory Technologies to Support Inquiry-Based Science Learning”; 6th IEEE International Conference on Wireless, Mobile, and Ubiquitous Technologies in Education; April 2010; Kaohsiung, Taiwan; ISBN: 978-0-7695-3992-8
14. The EC’s Ethical Guidelines: ftp://ftp.cordis.europa.eu/pub/fp7/docs/guidelines-annex5ict.pdf